The NipcoFlex shoe calender – Development and operating experience


Dr. Jörg Rheims
Finishing
joerg.rheims@voith.com


Dr. Rüdiger Kurtz
Paper Machines Graphic
ruediger.kurtz@voith.com

Based on excellent results with the shoe press, Voith Paper started developing the shoe calender in the early nineties. The foundations were laid and several patents were taken out, but the market situation soon demanded concentration on the Janus calender. Development work on the shoe calender started again in 2000, and in December 2001 the NipcoFlex calender test facility was commissioned.

Basic design and operating principle

The NipcoFlex calender comprises a heated Flexitherm roll pressing against a NipcoFlex roll with soft cover and rigid concave shoe (Fig. 1). Between the NipcoFlex sleeve and Flexitherm roll the paper is calendered on the side in contact with the latter. Important for wide-nip calendering are above all the QualiFlex Cal sleeve with its special characteristics (surface smoothness, hardness, thermal capacity and mechanical strength), and the shoe itself (nip length, MD line force profile, lubricating system between sleeve and shoe).

The principle of shoe calendering is based on the effects of moisture and temperature gradients (Fig. 2). The longer nip has a greater influence on calendering, which is further enhanced by the high temperature. This allows a significant reduction of line force and, therefore, the required pressure and enables the desired volume retention.

The NipcoFlex calender test unit

The NipcoFlex calender test unit shown in Fig. 3 is completed with a humidifier (steam or water) in front of the nip. In

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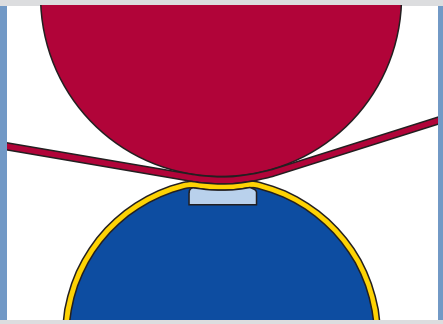

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Moisture and temperature gradient calendering

Nip pressure reduction, while preserving bulk

Contour calendering by NipcoFlex calender
– Soft sleeve adapts to macro surface structure
– Mainly micro roughness improved (PPS)
– Macro roughness (Bendtsen) improved less significantly

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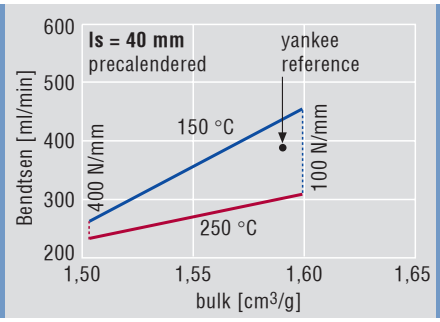

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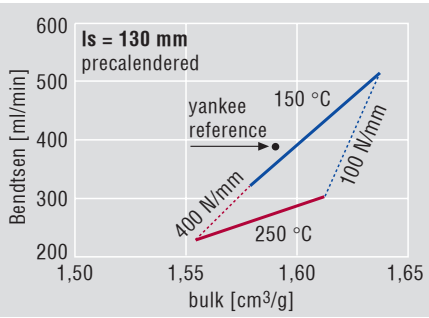

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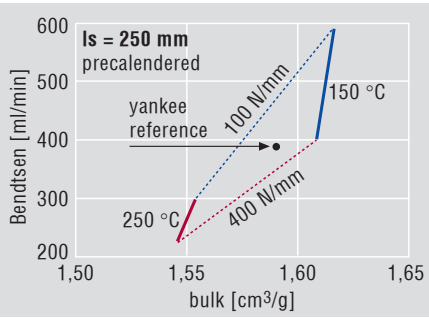

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combination with the second stack, online pre-calendering or post-calendering (reverse sheet side) with hard or soft rolls is also possible.

The NipcoFlex calender test unit can be operated at speeds of up to 1,500 m/min, line forces of up to 1,200 N/mm and maximum roll surface temperatures up to around 260 °C.

Nip lengths can be varied between 40 and 250 mm, the shorter nips mainly being used for graphic grades and the longer nips for carton.

Since December 2001 numerous tests have been carried out over a wide range of basis weights, from folding boxboard at 370 g/m^2 down to graphic paper at 40 g/m^2.

The NipcoFlex calender for board and packaging paper

In many board machines volume retention is achieved by calendering with a Yankee cylinder, which however has the drawback of restricted operating conditions with regard to production speed and output. In the end, the principle of gentle bulk-retaining calendering leads to the wide-nip or shoe calender.

NipcoFlex calender in comparison to the Yankee cylinder

Nip length is a very important parameter in shoe calendering, because it determines how long the pressure, temperature and humidification take effect. **Figs. 4, 5 and 6** show calendering results on uncoated white lined chipboard – WLC (basis weight about 370 g/m^2) with nip lengths of 40, 130 and 250 mm. The continuous lines in these diagrams show the relation between macro-roughness (Bendtsen) and specific bulk at temperatures of 150 °C (blue) and 250 °C (red) with linear load variation from 100 to 400 N/mm. The dotted lines show this relation at constant linear load and varying temperature. Overall, these curves define the operating range at these calender settings.

Using the shortest 40 mm shoe **(Fig. 4)**, temperature variations have no effect on calendering results. Compared with the reference point, a higher bulk than with a Yankee cylinder is only attained at low linear loads. This nip is clearly too short for the relatively heavy board, and results are similar to those with a soft calender.

At 130 mm nip length **(Fig. 5)**, however, the bulk changes significantly also with temperature. Furthermore, shoe calendering results exceed those at the reference point over a wide range. If the calender nip length is further increased to 250 mm **(Fig. 6)**, these results are hardly improved because, due to the long dwell time, temperature has a greater effect than linear load.

As a further comparison between the NipcoFlex calender and Yankee cylinder with white lined chipboard, **Fig. 7** shows the relation between micro-roughness of

Fig. 1: *The NipcoFlex calendering principle.*

Fig. 2: *Surface quality improvement with NipcoFlex calender.*

Fig. 3: *NipcoFlex calender test unit.*

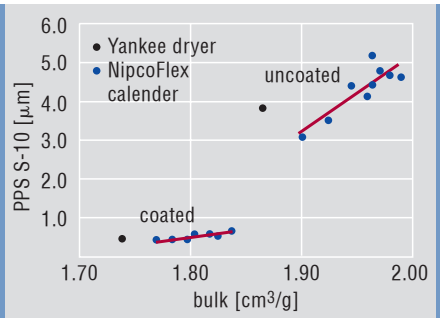
Abb. 4: *NipcoFlex calender, nip length 40 mm, precalendered with hard nip, white lined chipboard.*

Fig. 5: *Nip length 130 mm.*

Fig. 6: *Nip length 250 mm.*

Fig. 7: *Folding boxboard: Yankee cylinder versus NipcoFlex calender.*

Fig. 8: *Operating window for liquid board: comparison between soft calender and NipcoFlex calender.*



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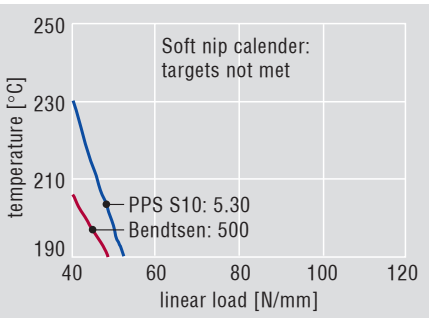

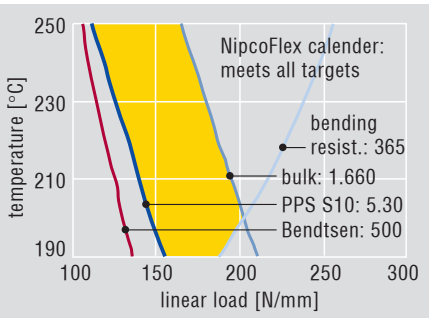

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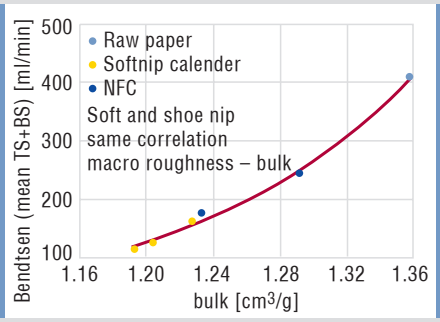

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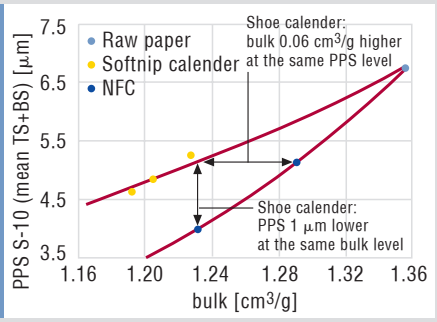

Fig. 9: *NipcoFlex calendering of copy paper (80 g/m²): macro-roughness.*

Fig. 10: *NipcoFlex calendering of copy paper (80 g/m²): micro-roughness.*

Fig. 11: *StoraEnso Baienfurt BM 3 project.*

Fig. 12: *NipcoFlex calender.*

Fig. 13: *StoraEnso Baienfurt BM 3.*

the board surface (PPS S-10) and bulk before and after coating. The NipcoFlex calender attains the same PPS level as the Yankee cylinder, but with up to 4 % more bulk and at 40 % higher speed. This effectively eliminates the bottleneck caused by the Yankee cylinder.

NipcoFlex calendering in comparison to the soft calender

Fig. 8 shows this comparison based on test data with liquid packaging board. Using a process optimization software, the respective operating window was determined each time. In the present case no operating window remains with soft-calendering: surface quality requirements are fulfilled, but the bulk is inadequate. With the NipcoFlex calender, however, all requirements are exceeded within the yellow range.

The NipcoFlex calender for graphic grades

NipcoFlex calender in comparison to the soft calender

Soft calenders are used for grades such as copy paper or matt coated wood-free papers. Here NipcoFlex calendering offers the advantage of a possibly higher bulk, with savings in fibers and lower operating costs accordingly.

Figs. 9 and 10 compare results for 2-sided calendered copy paper (80 g/m²).

Fig. 9 shows Bendtsen macro-roughness plotted over specific bulk. Here there is practically no difference between the two calendering methods. But referred to PPS S-10 micro-roughness (Fig. 10), there is a very clear difference: bulk with the NipcoFlex calender is 5 % or 0.06 cm³/g higher at the same PPS value, while smoothness improves by about 1 µm or 20 % at the same bulk.

NipcoFlex calendering in comparison to the Janus calender

The Janus calender is currently used for graphic grades with high demands on surface quality, such as SC or LWC papers. Based on this technology, demands for still better surface quality and higher production speeds can only be met by further increasing the number of nips. However, this is unreasonable both technologically and with regard to investment and operating costs. Here again, the NipcoFlex calender might be the answer.

In order to equal the calendering performance of multiple-nip Janus technology with a single NipcoFlex calender nip per sheet side, short nips with high line forces and/or high roll surface temperatures (well over 200 °C) are required. This reaches the maximum sleeve loading limits, and while tests so far have shown the potential of NipcoFlex calendering technology, they have also revealed its current limitations. Voith Paper, therefore, has a lot of development and optimization work to do in the near future.

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Project

Rebuild of White Lined Chipboard Machine
width: 4.8 m, speed: 750 m/min

Scope

NipcoFlex shoe press
NipcoFlex shoe calender (at 250 °C), Sirius reel

Target

1. step: increase production ~ 35.000 t/a (20%)
2. step: replace Yankee cylinder (approx. 25%)

February 2004:
production restart after rebuild BM 3

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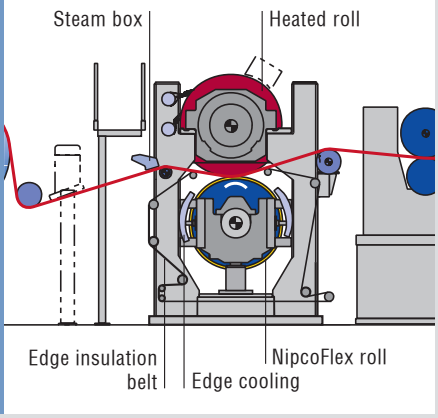

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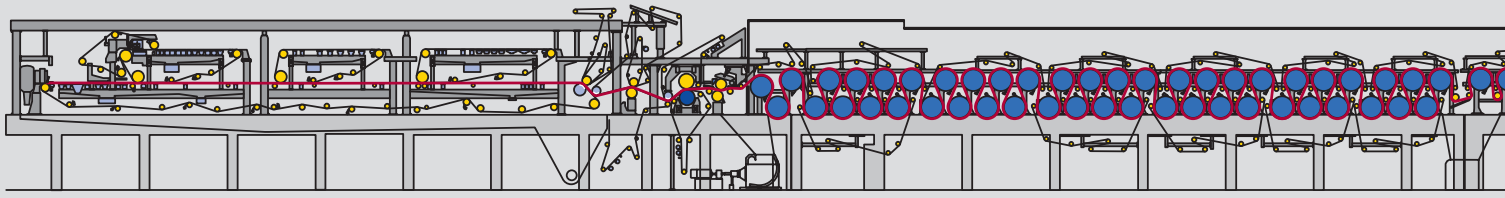

Fig. 14: *Design data of the Baienfurt BM 3 NipcoFlex calender.*

Fig. 15: *NipcoFlex calender in Baienfurt BM 3.*

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Design speed	850 m/min	
Heated roll surface temperature	250 °C in operation	
Line force	max. 500 N/mm	
Nip length	190 mm (130, 250 mm possible)	
Shoe tilt (load change at in- and outgoing side)	+/- 20 %	

NipcoFlex calender in practice – operating experience at StoraEnso Baienfurt, BM 3

NipcoFlex calender technology

Fig. 11 summarizes the decisive goals of this rebuild, particularly with regard to the planned 25 % production increase in future by completely replacing the Yankee cylinder with a shoe calender.

In this rebuilt board machine **(Fig. 13)** the NipcoFlex calender is not located in the relatively damp board production process zone, where the Yankee cylinder is currently situated, but directly in front of the coating machine where the web has a much higher dryness.

Fig. 12 shows the detailed layout of the NipcoFlex calender. The top roll is inductively heated to a surface temperature reaching 250 °C during operation. The NipcoFlex bottom roll enables shoe changes for nip length variation. Since calendering is online, both rolls have to be driven.

To prevent roll sleeve melting due to the high temperature of the top roll at the edge zones outside the board web, direct contact is avoided by changing the operating mode compared with shoe presses.

The NipcoFlex calender shoe is, therefore, retracted from the bottom roll periphery, and the roll edges are cooled by compressed air and cold water nozzles.

Board surface quality is improved by a steam blow box located in front of the nip above the web. The steam condensation increases surface smoothness.

The rolls and NipcoFlex roll sleeve are changed in the same way as with shoe presses.

Fig. 14 summarizes the main design and operating parameters of this machine. Three different nip lengths are available for optimizing board quality. A 190 mm nip was used at start-up, because that gave the best results in the previous pilot tests.

Fig. 15 shows the NipcoFlex calender in operation on board machine BM 3 in Baienfurt.

Operating experience

Commissioning followed an optimization plan based on experience with the pilot machine. Fig. 16 summarizes the first operating results immediately after start-up, showing the quality and printability data for 215 g/m^2 folding boxboard.

All the positive pilot test results were confirmed without exception during commercial operation.

With the rebuild, two important changes were decisive for the board structure in the z-direction and for the surface quality:

- Drainage through a double-felted shoe press with downstream offset press

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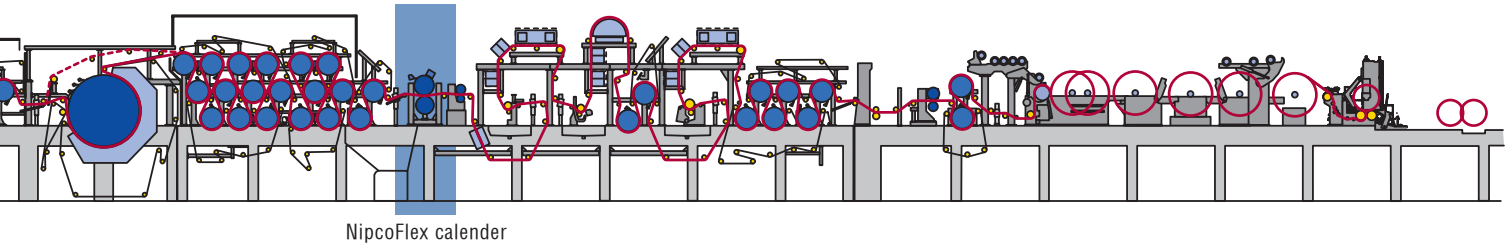

NipcoFlex calender

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Required technological standard	Before rebuild w. Yankee/grade 1	After rebuild w. NFC/grade 1
BW total [g/m^2]	220	215
Speed [m/min]	440	470
Bulk [cm^3/g]	1,48 +/- 3 %	= (+)
Mean bending Stiffness [mNm]	9,6 - 10,7	=
PPS roughness [µm]	1,3 - 1,6	= (+)
Printability	mottle free, good gloss and brightness	= (+)

instead of conventional individual presses (but still one press less in total)
- NipcoFlex calendering through a long high-temperature nip, without using the Yankee cylinder.

It, therefore, had to be determined whether the board structure was changed enough to affect subsequent processes (coating, printing), or whether the difference in surface quality and z-direction structure was only marginal.

This question can be answered in part by comparing the SEM (scanning electron microscope) photographs taken in three production phases **(Fig. 17)** – with individual presses and Yankee cylinder prior to rebuild, with shoe press and Yankee cylinder after rebuild, and finally with shoe press and NipcoFlex calender after rebuild.

As shown in these pictures, there are only minimal differences in the z-direction web structure. Moreover the excellent printing results prove that the effect of these differences is negligible.

Summary and future prospects

The tests carried out by Voith Paper over the last three years show great potential for the NipcoFlex calender.

The world's first wide-nip calender for folding boxboard production started commercial operation on February 1, 2004 in board machine BM 3 at Stora Enso Baienfurt/Germany. **Fig. 18** summarizes the operating experience and advantages so far with this NipcoFlex calender.

In the second quarter 2006 Voith Paper will start up a NipcoFlex calender at Weyerhaeuser Longview (USA) for liquid packaging board production. In the same year further machines already ordered will be installed, also for graphic grades.

Fig. 16: *Post-commissioning operating experience.*

Fig. 17: *SEM analysis of Yankee roll and NipcoFlex calendering results.*

Fig. 18: *Production benefits and future potential.*

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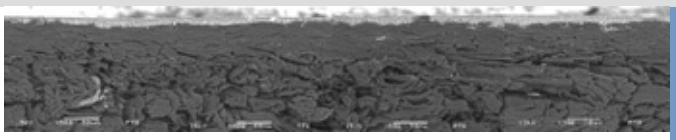
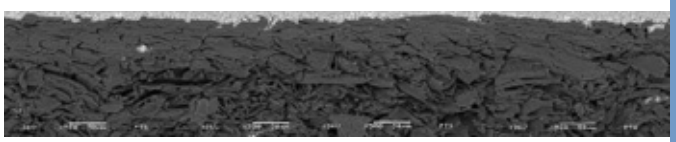
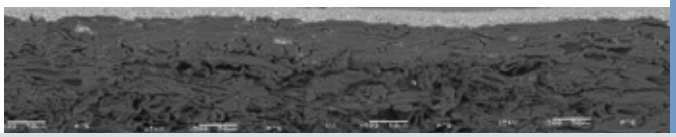
Before rebuild with old press and Yankee



After rebuild with new NipcoFlex press and Yankee



After rebuild with NipcoFlex press and new NipcoFlex calender



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Quality targets with shoe calendering after first production runs fulfilled and printability as brilliant as before rebuild

Efficiency and runability as good as expected

Speed increase without lack in quality possible

Rebuild target to increase production by further 25% and replacement of Yankee seems reasonable

NipcoFlex calendering fulfills product development and rebuild objective